

The Design and Use of Patents*

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Innovation. Economists estimate that a large fraction of the improvements in living standards enjoyed by industrialized nations over the past fifty to one hundred years are due to innovation. Public officials repeatedly emphasize that they favor policies promoting innovation. Business executives, worrying as usual about falling behind their rivals and striving to gain competitive advantage, are endlessly looking for ways to make their organizations innovative. Business magazines rank companies based on their effectiveness as innovators. My own school, the Haas School of Business at the University of California at Berkeley, recently adopted “Leading Through Innovation” as its theme. “Innovation” is today’s magic word in business.

As befits such a broad and complex subject, commercial innovation has been studied from many different perspectives. Some scholars and practitioners emphasize how organizational structure, corporate culture, and leadership affect innovation. Others study the role of the financial system, including investment bankers and venture capitalists. Some focus on start-up companies and the mechanisms by which their ideas are absorbed into or copied by larger organizations. Yet others focus on social networks, collaboration across organizational boundaries, and the regional advantages of locales like Silicon Valley. Another group looks at educational systems, universities, and government sponsored research. All of these approaches are valuable.

* This document covers material discussed in my lecture in Madrid on 17 April 2007. I am in the process of developing these ideas into a book to be published by Cambridge University Press. This forthcoming book will explore the ideas presented here much more extensively and provide additional citations to the relevant literature. Pending the publication of the book, those interested in exploring these topics more deeply are encouraged to read my related papers, all of which are available on my web site, <http://faculty.haas.berkeley.edu/shapiro>, and to pursue the citations provided in these papers: [Patent Reform: Aligning Reward and Contribution](#), April 2007; [Probabilistic Patents](#), with Mark Lemley, *Journal of Economic Perspectives*, 2005; [How Strong Are Weak Patents?](#), with Joe Farrell, January 2007; [Injunctions, Hold-Up, and Patent Royalties](#), August 2006; [Patent Hold-Up and Royalty Stacking](#), with Mark Lemley, January 2007; [Prior User Rights](#), May 2006; and [Standard Setting, Patents, and Hold-Up](#), with Joe Farrell, John Hayes, and Theresa Sullivan, April 2007. See the first two papers especially for references to the relevant literature supporting various factual assertions made below.

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Today, I will focus on one aspect of innovation which lies at the intersection of economics, management, and the law: intellectual property. Actually, I will devote the bulk of my lecture to one particular form of intellectual property: patents. I will touch briefly on trade secrets and know-how. I will mention copyrights only in passing. There is plenty to say about patents alone.

1. The Shifting Role of Patents in the United States

When I teach competitive strategy to business students, we spend a lot of time talking about “sustainable competitive advantage.” I like to emphasize that most sources of competitive advantage are transitory, and learning to sustain such advantages is just as important as learning to create them in the first place. Given my location in Berkeley, I often study high-tech industries, where the transitory nature of competitive advantage is especially clear. Nintendo dominated the video game industry from the mid-1980s into the mid-1990s, winning against Atari and Sega, but has seen its advantage greatly eroded over the past decade due to competition from Sony and Microsoft. Dell Computer built a highly successful and profitable company during the 1990s with improved business methods for making and selling personal computers, only to see its advantage erode in recent years as other companies have copied its methods. Competitive advantage can also be fleeting in traditional manufacturing industries, where successful practices can be imitated and cost advantages can shift as quickly as exchange rates.

What types of competitive advantage tend to be most durable?

Some companies with a “culture of innovation” seem to do very well over a sustained period of time, regularly introducing new and improved products and adopting state-of-the-art business practices. Apple Computer is often cited as highly innovative, with much credit given to Steve Jobs, the “innovator in chief.” Last year, *Business Week* ranked Apple as the most innovative large global corporation. I applaud companies that have a “culture of innovation.” But as an economist, I do not claim to know how to advise companies to build one. True to my training, I tend to think about competitive advantage in conventional economic terms: lower costs or better products, protected by barriers to entry. In today’s global economy, it is becoming harder and harder to maintain an advantage based on lower input costs or based on keeping rivals from imitating successful products. Which brings us to patents.

Patents and trade secrets are the central legal mechanisms by which firms today seek to protect their innovations from being copied by rivals, a critical requirement if the competitive advantage flowing from innovation is to be sustained.¹ In the industrial era, competitive advantage and barriers to entry often revolved around scale economies and favorable locations, which could provide access to low-cost raw materials and/or lower transportation costs to market. Economists studied these factors closely, and, of course, they remain important today in many industries. Patents and know-how certainly played a role in some industries, but not to the same extent that they do now in high-tech industries, where they often form the basis for competitive

¹ Of course, copyrights play this role, too, primarily in the area of content creation. My focus here is on technical areas in which the primary intellectual property protection comes from patents and trade secrets, not copyrights.

advantage and barriers to entry. During the past twenty years, these forms of intellectual property have played a larger and larger role in business strategy, especially in the information, communications, and biotechnology industries, which in turn has led more and more economists to study the impact of trade secrets and patents on innovation and competitive advantage.

Worldwide patent data can help us see where patents are more or less important. The distribution of patents granted by different patent offices is highly skewed. In 2004, about 75% of patent applications and patents granted worldwide were in five offices: the United States, Japan, the European Patent Office, China, and the Republic of Korea.² I know the most about the U.S. patent system, and much of the scholarly empirical work done so far examines U.S. patents, so I will focus my attention there. I know much less about the operations of the patent systems in Japan, China, and Korea. And here I am in Spain. So, after I discuss the design and use of patents in the U.S., I will compare the U.S. with the European Union.

There is strong evidence that patents are playing an increasingly important, and shifting, role in the U.S. As with so many things, good and bad, the U.S. has blazed its own path in the area of patents. Whether other industrialized nations will emulate the U.S. remains to be seen. Even if they do not, companies seeking to do business in the U.S. must deal with the U.S. system.

In 2006, about 444,000 patent applications were filed in the U.S., up from 206,000 in 1996 and only 131,000 in 1986.³ The growth rate in patent applications over the past decade has been about 8.0% per year. In 2006, about 183,000 patents were issued, up from 117,000 in 1996 and only 77,000 in 1986.⁴ The growth rate in patent grants over the past decade has been about 4.6% per year. While these figures might suggest that only about half of applications are granted, and that the U.S. Patent and Trademark Office (USPTO) is getting tougher on patent applicants, reality is more complex, for two primary reasons. First, there is a rapidly growing backlog of patent applications. The number of pending applications surpassed one million in 2006.⁵ The backlog has grown at about 12.7% per year over the past decade. Second, many applications are “continuation applications,” in which patent applicants reapply for patents previously denied. Correcting for these factors, the USPTO grants around 85% of patent applications. This is a much higher rate than at the European Patent Office (EPO) or the Japanese Patent Office (JPO). The EPO also has experienced a sharp rise in the number of patent applications over the past decade and is coming under increasing pressure as its backlog of pending patents grows.

Unfortunately, the U.S. patent system has experienced a complex of related problems that are undermining its effectiveness as a means of promoting innovation. Several influential studies have concluded that the USPTO is plagued by problems of patent quality, frequently issuing

² Source: [WIPO Patent Report, Statistics on Worldwide Patent Activities](#), p.4, World Intellectual Property Organization, 2006.

³ [Performance and Accountability Report](#), Table 2, U.S. Patent and Trademark Office, Fiscal Year 2006.

⁴ [Performance and Accountability Report](#), Table 6, U.S. Patent and Trademark Office, Fiscal Year 2006.

⁵ [Performance and Accountability Report](#), Table 3, U.S. Patent and Trademark Office, Fiscal Year 2006.

patents to applicants who have not in fact made new and non-obvious discoveries.⁶ The USPTO lacks resources to process the flood of patent applications and can have difficulty identifying suitable “prior art.” In fact, something of a vicious cycle has arisen: the more applications are filed, the less time the PTO has to process each one, making it more likely that an unworthy application will be approved, which encourages yet more patent applications. Despite problems of patent quality, all patents are presumed by the courts to be valid, meaning that alleged infringers are required to present “clear and convincing” evidence to have them invalidated.

Under U.S. patent law, a patent should not be granted if the patent application describes something that would have been obvious at the time to a “person having ordinary skill in the art.” The Federal Circuit Court of Appeals, the special court established to handle patent cases, has defined “obviousness” narrowly, thereby allowing many firms to obtain patents when they did little if any real innovation. Fortunately, the U.S. Supreme Court is now reviewing the Federal Circuit’s obviousness test.⁷ In the pending case, *Teleflex* received a patent covering gas pedals that combine two features: (1) they are adjustable, to fit drivers of different heights, and (2) they send an electronic signal to the engine when the driver presses down, rather than relying on a mechanical cable. Both features had been in the industry for years when *Teleflex* applied for its patent, but *Teleflex* was able to obtain a patent on combining them. Applying its test, the Federal Circuit ruled that the combination was not obvious, but the Supreme Court may well overrule them and establish a standard under which more patent applications would be rejected as describing technology that is obvious.

The problems with the U.S. patent system are not confined to the issuance of patents. A number of scholars have examined and documented the ways in which the U.S. system of patent litigation has shifted in favor of patent holders over the past 25 years, since the establishment of the specialized patent court, the Court of Appeals for the Federal Circuit (CAFC). Even as the courts have lowered the bar for obtaining a patent, they have made it possible for patent holders to obtain larger and larger damage awards from infringers. As a result, patents have become both easier to get and more valuable. Not surprisingly, firms have become more and more aggressive about obtaining and enforcing their patents.

Systematic and comprehensive evidence on patent litigation and patent damages is difficult to obtain, but there clearly has been a sharp increase in patent litigation and damages in the U.S. over the past decade. The number of patent infringement cases filed has grown steadily, at 7.7% per year over the past fifteen years; over 3000 cases were filed in 2004.⁸ On top of this, the average patent damages award has grown from around \$5 million in the early 1990s to nearly \$20 million today.⁹ This average is greatly affected by the very largest awards, which have

⁶ See Adam Jaffe and Josh Lerner, *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It*, 2004; Federal Trade Commission, *To Promote Innovation: The Proper Balance Between Competition and Patent Law and Policy*, 2003; and National Academies of Science, *A Patent System for the 21st Century*, 2004.

⁷ *KSR v. Teleflex*, Case No. 04-1350.

⁸ “2006 Patent and Trademark Damages Study,” p. 7, PriceWaterhouseCoopers.

⁹ “2006 Patent and Trademark Damages Study,” p. 11, PriceWaterhouseCoopers.

skyrocketed. The most recent stunning example is the \$1.52 billion verdict against Microsoft for infringing patents owned by Alcatel-Lucent on the MP3 music format.¹⁰ Awards like this inevitably encourage other patents holders to file patent infringement cases and see if they, too, can win the lottery. Many of the largest patent awards are made by juries rather than judges.¹¹

In some industries, such as the semiconductor industry, the flawed U.S. patent system is creating an “arms race” with the game-theoretic structure of the prisoners’ dilemma: as patents become easier to get and more valuable, each company applies for and obtains more patents, posing a greater threat to its rivals, who then seek more patents themselves. The net result is that the USPTO is issuing many more semiconductor patents in total. But these surge of patenting represented more than just innovation in this industry. Rather, the “patent propensity” of leading semiconductor companies has gone up: they are obtaining more patents relative to their R&D spending. And they are primarily using these patents defensively, as bargaining chips in case they are sued. Firms outside the industry, and firms exiting the industry or segments of it, are the ones using these patents offensively.¹² Along similar lines, the impact of court decisions strengthening software patents was to depress, not boost, the value of software firms.¹³ Something is askew in a system that promotes patenting to defend against litigation, rather than to protect innovation.

More generally, there is evidence that firms in a number of industries adjusted their strategies in the 1980s and early 1990s in response to changes in the patent system: they began seeking more patents, but not because they were devoting more resources to R&D. A 1994 survey of R&D labs in U.S. manufacturing companies showed that patents were considered less important than trade secrets and lead time in appropriating the returns from R&D. Furthermore, patents were often sought for defensive reasons: to block rivals from getting patents and to use in negotiations and to prevent litigation.¹⁴

The documented shifts in the U.S. patent system are of considerable interest and importance to scholars who study the U.S. patent system and to public policy makers who fashion that system. For obvious reasons, they also can directly affect the strategies of firms that hold or seek U.S. patents. But their importance extends to a great many companies doing business in the U.S., especially if they operate in the information and communication technology sector, broadly defined. Such companies may be unpleasantly surprised to find themselves defending a patent infringement case in the U.S., even if they never knowingly adopted any patented technology. Furthermore, scholars and public policy makers in other countries can learn from the U.S.

¹⁰ See “MP3 Patents in Upheaval After Verdict,” by Saul Hansell, *New York Times*, 23 February 2007. In contrast, Microsoft paid only \$16 million to Thompson to license many other MP3 patents from a consortium.

¹¹ “2006 Patent and Trademark Damages Study,” p. 16, PriceWaterhouseCoopers.

¹² See “An Empirical Analysis of Patent Litigation in the Semiconductor Industry,” Bronwyn Hall and Rosemarie Ziedonis, January 2007.

¹³ See Bronwyn Hall and Megan MacGarvey, “The Private Value of Software Patents,” NBER Working Paper No. 12195, Revised April 2007.

¹⁴ See Wesley Cohen, Richard Nelson, and John Walsh, “Protecting Their Intellectual Assets: Why U.S. Manufacturing Firms Patent (Or Not),” NBER Working Paper No. 7552, 2000.

experience. Indeed, one of my main messages here this evening is that there is much to learn from the mistakes made by the U.S. in patent policy over the past twenty years.

2. More Patents, Less Innovation?

The notion that more patents, and stronger patents, may stifle rather than promote innovation may seem strange. We tend to think of patents as rewards for innovation, so “more patents” reflects “more innovation.” We tend to think of innovation as creating spillovers, due to imperfect appropriability, so “stronger patents” means greater appropriability, which may seem both fair and efficient.

Unfortunately, however, the activity of filing for (and enforcing) patents is quite distinct from the activity of engaging in research and development (R&D). To oversimplify greatly, filing for patents involves hiring lawyers, while conducting R&D involves hiring scientists and engineers. More seriously, we need to distinguish the return to patenting from the return to conducting R&D. In fact, the evidence is mounting that many of the changes in the U.S. patent system over the past twenty years, under which the requirements for obtaining a patent have been reduced even while the rights awarded to patent holders have been strengthened, are stifling rather than promoting innovation. For example, while the semiconductor industry is obviously highly innovative, it appears that recent shifts in the patent system have reduced the design freedom of semiconductor firms and imposed excessive costs in the form of patent damages and patent royalties on semiconductor firms vulnerable to accusations of patent infringement.

My work on patents has focused on several related economic problems that arise systematically under the current U.S. patent system. When these problems are present and significant, they reduce the return on innovation for non-patent holders and thus stifle innovation. The problems listed below are especially pronounced in the information technology sector, although they are certainly not confined to that sector.¹⁵ A discussion of any one of these problems could form the basis for an entire lecture; here I will simply list and define these problems and indicate how they relate to features of the patent system. See especially my paper “Patent Reform: Aligning Reward and Contribution,” for further discussion of these points. All of these ideas, and more, will be developed extensively in the forthcoming book from Cambridge University Press.

- **Patent Hold-Up:** a variation on traditional problems of hold-up and opportunism that arises when a technology user has made investments that are specific to the patented technology. This problem is especially severe if the patent holder can obtain an injunction to prevent the technology user from selling products that make use of the patented technology.¹⁶ The patent hold-up problem is exacerbated by poor patent quality.

¹⁵ These and other related problems are growing as the scope of what can be patented expands. Patents in the U.S. can cover not only software but genes, biotech tools, business methods, and even tax strategies.

¹⁶ The Supreme Court recently and helpfully gave the lower courts greater flexibility to determine whether patent holders should obtain injunctions; see *eBay v. MercExchange*. Previously, the Court of Appeals for the Federal Circuit had issued injunctions virtually automatically.

It can be reduced by opening up the examination process to help the PTO identify prior art, by improving post-grant opposition, and by establishing broader prior user rights.

- **Patent Ambush of Product Standards:** This an especially dangerous variant of patent hold-up that arises for patents essential to comply with a product standard. Standard setting organizations can reduce the danger of patent ambush by adopting effective rules requiring patent holders to disclose and license their essential patents on “fair, reasonable, and non-discriminatory” (FRAND) terms. Prior user rights can also help solve this problem. Enlightened competition policy can complement SSO rules while giving members of standard setting organizations suitable flexibility to prevent or limit patent ambush.
- **Excessive Rewards with Multiple Independent Invention:** When two or more parties achieve the same invention at roughly the same time, awarding one with exclusive rights can be a highly inefficient method of rewarding innovation. This problem is especially severe if the non-obviousness standard is set low, so many patents are granted for minor improvements which are likely to be achieved by multiple parties at modest cost and roughly the same time. Granting prior user rights to those who independently achieve the same invention at an early date can improve efficiency and help solve hold-up problems.
- **Licensing of Weak Patents:** Patents are probabilistic property rights. When weak patents are issued, challenging them and invalidating the patent is a public good. Owners of weak patents who license them to competing downstream firms can exploit the public good nature of challenges to obtain excessive rewards. This problem can be reduced by improving patent quality, such as by using a peer-to-patent system like the one advocated by IBM.¹⁷ An especially promising way to reduce this problem is to establish an effective system by which patents can be challenged through re-examination or opposition soon after they are issued and before they are licensed.
- **Royalty Stacking:** Complex products can potentially infringe on hundreds or even thousands of patents. This creates a situation with the same features as the classic problem of Cournot complements, which can lead to inefficiently high royalty rates.¹⁸ While cross licenses and patent pools can help solve the problem, individual patent holders may be tempted to hold out for higher royalties. This problem can be reduced by making the “non-obviousness” requirement more stringent and by limiting the ability of patent holders to obtain injunctions in some situations.
- **Excessive Damages:** This problem refers to patent damages awards that do not reflect the underlying value of the patented technology. In cases where damages are based on

¹⁷ See, “Open Call from Patent Office,” by Alan Sipress, *Washington Post*, 5 March 2007 and “Hoping to Be a Model, I.B.M. Will Put its Patent Filings Online,” by Steve Lohr, *New York Times*, 26 September 2006.

¹⁸ See Carl Shapiro, “Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standards,” NBER Innovation Policy and the Economy, Adam Jaffe, Josh Lerner, and Scott Stern, eds., 2000.

reasonable royalties for complex products, care must be taken to insure that the royalty rate reflects the value of the patented feature, not the value of the entire product.

Let me pause here to give two examples that illustrate some of these problems.

In the early 1990s, in an effort to improve air quality, California developed rules requiring that gasoline sold in California burn more cleanly. Gasoline refiners and automobile companies were consulted, and various alternatives for “reformulated gasoline” were considered. One oil company, Unocal, performed some tests to examine the relationship between various gasoline attributes and harmful emissions. Other companies were performing similar tests at the same time, but Unocal’s tests were the most systematic at the time they were done. Unocal shared its results with industry members while secretly filing for patents on the statistical relationships they had uncovered. After California put its new rules in place and refineries invested billions of dollars in their refineries to comply with those rules, Unocal asserted that a large fraction of all the reformulated gasoline infringed its patents. Unocal sued several refineries for patent infringement for one of its patents, and won. Unocal was awarded tens of millions of dollars of infringement damages in an initial round and sought hundreds of millions more. Later, the Federal Trade Commission sued Unocal for acting deceptively and for monopolization.¹⁹ The Unocal case illustrates how the U.S. patent system can provide a huge reward to the owner of a patent that can be used opportunistically against other firms who have made large investments that are specific to the patented technology. In such cases, much of the patent holder’s return can result from hold-up, not from innovation. The Unocal case is a good example of patent hold-up, patent ambush with product standards, and excessive rewards with multiple invention.

A more recent and better known example involves the popular BlackBerry wireless e-mail device. NTP, a patent holding company, claimed that RIM, the provider of the BlackBerry, had infringed several of NTP’s patents. After a jury found NTP’s patents valid and infringed by RIM, NTP asked the court to issue an injunction to stop RIM from selling infringing BlackBerry devices. As a result, RIM came under enormous pressure to settle the case to avoid a shutdown of the BlackBerry service, which could have resulted from a court injunction forcing RIM to stop infringing NTP’s patents. In March 2006, RIM paid \$612.5 million to NTP to settle the case.²⁰ The magnitude of this payment reflected the strong bargaining position NTP enjoyed by virtue of its threat to shut down BlackBerry service, not the underlying value of NTP’s patented technology or the strength of its patents at the time. The NTP case is a good example of patent hold-up and the licensing of weak patents. Note that *Business Week* listed RIM, not NTP, as one of the most innovative companies in 2006.

¹⁹ I served as an economic expert witness for the FTC when it challenged Unocal’s conduct. The case was subsequently settled when Unocal was acquired by Chevron, which agreed not to assert the relevant patents against refiners producing gas to comply with the California regulations.

²⁰ See “RIM to Pay NTP \$612.5 Million to Settle BlackBerry Patent Suit,” *Wall Street Journal*, March 4, 2006.

3. Lessons for Patent Policy and Competitive Strategy

If patents are strong and relatively easy to get, profit-maximizing companies will find ways to apply and receive more patents. This may not entail more innovation. Rather, it can lead to a mutually destructive arms race with the structure of the prisoners' dilemma game, ultimately stifling rather than promoting innovation.

Companies can and will adjust their intellectual property strategies in multiple, creative ways to exploit opportunities created by whatever patent system they are facing. We have seen this in the U.S., especially with the rise of so-called "patent trolls" who may do little or nothing by way of actual innovation and may not even sell any products, but who are expert at exploiting patents and, some would say, holding up their victims using the patent system. Other intellectual property strategies and institutions are still being developed, including: (1) taking an inventory of a company's patents, looking for underexploited jewels, so-called "Rembrandts in the Attic;" (2) acquisition of previously unexploited patents by companies whose core competency is their ability to extract favorable license terms; (3) auctioning off patents, either singly or in bundles, and/or creating a marketplace in which patents can be bought and sold; and (4) securitization of the revenue streams associated with patent licensing; and If the patents at issue are truly deserved and the rewards to patentees are in line with their contributions, these new intellectual property strategies are to be welcomed. However, if patent quality is problematic and patent hold-up is a genuine danger, these new strategies may allow clever firms to exploit the patent system more quickly and more effectively without promoting innovation.

By this point in the evening, it should be clear that I am not here on a mission to export U.S. patent policy to Europe. Quite the contrary. In fact, the E.U. has avoided problems in several areas by refraining from copying aspects of the U.S. patent system. Four major differences stand out where the EU system appears to be superior:

- **Patent Quality:** The EPO has placed greater emphasis on patent quality than has the USPTO. Compare the two most recent annual reports by the USPTO and the EPO. The USPTO report begins by emphasizing the importance of strong intellectual property rights, stating: "it's critical that the United States Patent and Trademark Office (USPTO) continually improve and evolve to foster the growth and protection of our nation's valuable IP resources."²¹ The EPO report, by contrast, emphasizes at the outset that: "Quality is the key to the future of the European Patent System."²² Despite this statement, however, pressure has increased on the EPO to reduce backlogs, which could harm patent quality.²³

²¹ [Performance and Accountability Report](#), p.3, U.S. Patent and Trademark Office, Fiscal Year 2006.

²² [Annual Report 2005](#), p.4, European Patent Office.

²³ See Dietmar Harhoff, "Intellectual Property Rights in Europe – Where do We Stand and Where Should We Go?" September 2006.

- **Software Patents:** The EU has been much more cautious than the U.S. about issuing and enforcing software patents, although this remains a controversial area since the European Parliament vote in July 2005 against extending common software patent protection throughout the EU.
- **Patent Opposition System:** The EPO has an effective opposition system which is capable of weeding out many patents that should not have been issued. The U.S. still lacks an effective patent re-examination system.²⁴
- **Prior User Rights:** European countries generally grant prior user rights to a party that has developed and is using the patented invention before the patent holder applied for the patent.²⁵ For most of the past fifty years, U.S. patent law did not provide for prior user rights. Since 1999, U.S. patent law has included a provision for very limited prior user rights which apply only to business methods patents.

So far at least, the worst aspects of the U.S. system have not been adopted by the European Union. As your guest tonight here in Spain, I commend you for the aspects of your system that are working better than the U.S. system.

²⁴ See Stuart Graham, Bronwyn Hall, Dietmar Harhoff, and David Mowery, "Patent Quality Control: A Comparison of U.S. Patent Re-Examinations and European Patent Oppositions," in *Patents in the Knowledge-Based Economy*, Wesley Cohen and Stephen Merrill, eds., National Research Council of the National Academies of Science, 2003. See also Stuart Graham and Dietmar Harhoff, "Can Post-Grant Reviews Improve Patent System Design: A Twin Study of U.S. and European Patents," April 2006.

²⁵ I thank Dietmar Harhoff for providing me with information about prior user rights in Germany.